## Computers and Information Sciences
## Red Storm

(Left) Libyan Desert Glass is found in an area spanning 6500 km2, in the Great Sand Sea of the Western Desert of Egypt, near the border with Libya. In 1998, an Italian mineralogist showed that a carved scarab in King Tut's breastplate was made out of this glass.

# High performance computing provides clues to scientific mystery

*Enigmatic silica glass in the Sahara desert has survived nearly 30 million years. How did it form?*

Most natural glasses are volcanic in origin and have chemical compositions consistent with equilibrium fractional melting. The rare exceptions are tektites formed by shock melting associated with the hypervelocity impact of a comet or asteroid. Libyan Desert Glass does not fall into either category, and has baffled scientists since its discovery by British explorers in 1932. The 1994 collision of Comet Shoemaker-Levy 9 with Jupiter provided Sandia with a unique opportunity to model a hypervelocity atmospheric impact. Insights gained from those simulations and astronomical observations of the actual event have led to a deeper understanding of the geologic process of impacts on Earth and presented a likely scenario for the formation of Libyan Desert Glass.

Three-dimensional hydrocode simulations, requiring huge amounts of memory and processing power, support the hypothesis that the glass was formed by radiative heating and ablation of sandstone and alluvium near ground zero of a 100 Megaton or larger explosion resulting from the breakup of a comet or asteroid.

Using Sandia's Red Storm supercomputer, we ran high-resolution CTH shock-physics simulations to show how a 120-meter asteroid entering the atmosphere at 20 km/s (effective yield of about 110 Megatons) breaks up just before hitting the ground. This generates a fireball that remains in contact with the Earth's surface at temperatures exceeding the melting temperature of quartz for more than 20 seconds. Moreover, the air speed behind the blast wave exceeds several hundred meters per second during this time. These conditions are consistent with melting and ablation of the surface followed by rapid

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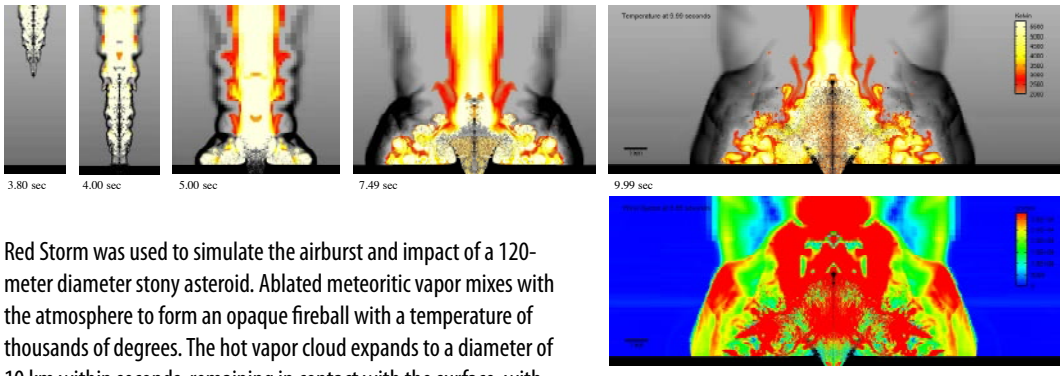


Red Storm was used to simulate the airburst and impact of a 120-meter diameter stony asteroid. Ablated meteoritic vapor mixes with the atmosphere to form an opaque fireball with a temperature of thousands of degrees. The hot vapor cloud expands to a diameter of 10 km within seconds, remaining in contact with the surface, with velocities of several 100 m/s. Simulations suggest strong coupling of thermal radiation to the ground, and efficient ablation of the resulting melt by the high-velocity shear flow.

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National Nuclear Security Administration

quenching to form the Libyan Desert Glass. These simulations require the massive parallel processing power provided with Red Storm.

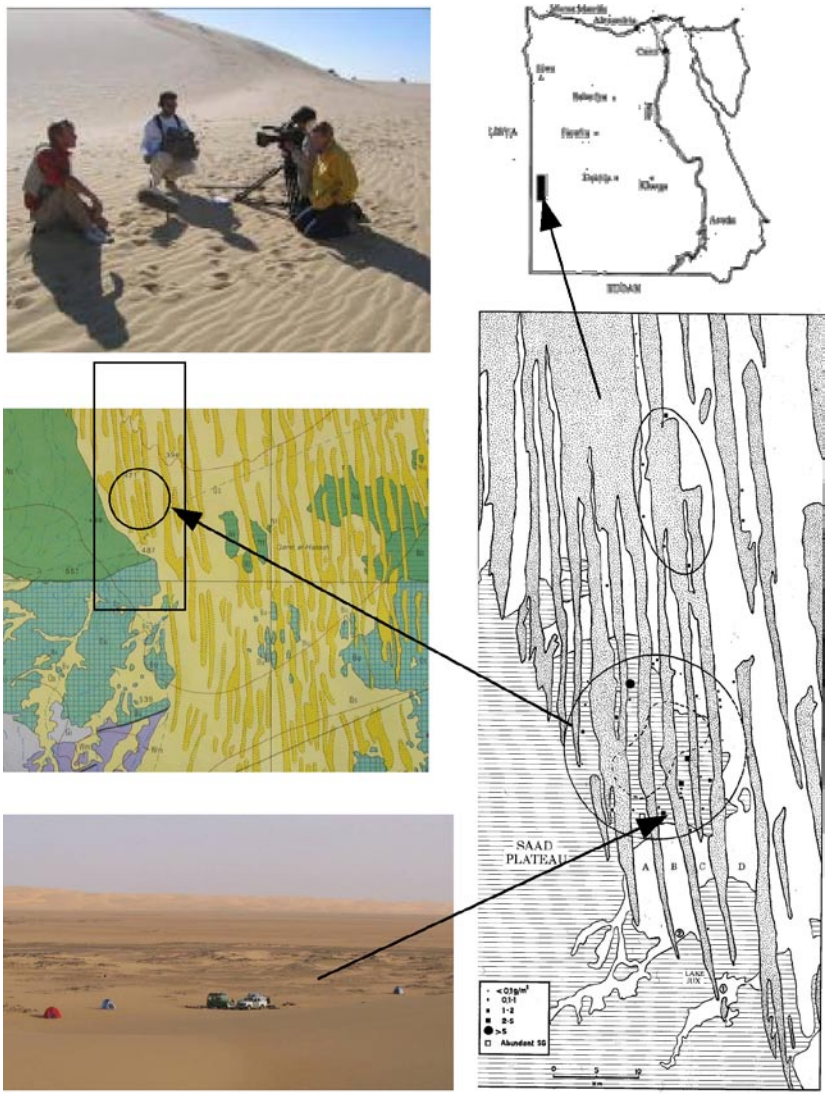
The risk to humans from such impacts is small but not negligible. Because of the low frequency of these events, the probability and consequences are both difficult to determine. The most likely scenario that would cause damage and casualties would not be a crater-forming impact, but a large aerial burst similar to the one that created this unusual natural glass. This research is forcing risk assessments to recognize and account for the process of large aerial bursts.

## NATIONAL GEOGRAPHIC DOCUMENTRY

In February, 2006, Mark Boslough participated in an expedition to the site of the Libyan Desert Glass (LDG). The glass has a fission-track age of about 29.5 Ma. There is little doubt that the glass is the product of an impact event, but the precise mechanism for its formation is still a matter of debate. This lively discussion was a featured element of the documentary.

Evidence for a direct impact includes the presence of shocked quartz grains and meteoritic material within the glass. However, the vast expanse of the glass and lack of an impact structure suggests the possibility of radiative/convective heating from an aerial burst.

"Ancient Asteroid" will be shown on the National Geographic Channel on Sept. 21, 2006.




Camp was set up in "corridor B" in the southern part of the Great Sand Sea, within the area of LDG concentration. Corridors consist of quaternary gravel and alluvium and are separated by linear dunes. The lower photograph is looking southeast. Geologic setting is shown by inset map. LDG sits on silica-rich weathered remains of Upper Cretaceous Nubia-Group sandstones. The main area of concentration is 20 km across.

Left: 120-meter asteroid explodes over the Egyptian desert in 2006 National Geographic documentary *Ancient Asteroid*.

Right: Documentary animators used Red Storm simulation to visualize the effect of an asteroid explosion in the atmosphere above the city of London.